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François Therin

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François THERIN

Groupe ESC Grenoble

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For further information:

Rahim BAH
Groupe ESC Grenoble
12 Rue Pierre Sémard
38003 Grenoble Cedex 01
rahim.bah@esc-grenoble.fr

LEARNING ORGANIZATION AND INNOVATION PERFORMANCE IN HIGH-TECH SMALL FIRMS

François THERIN

Grenoble Ecole de Management
12, Rue Pierre Semard
38000 Grenoble, France
Tel. : (+33) 476 706 109
Fax : (+33) 476 706 099
therin@esc-grenoble.com

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ABSTRACT :

The aim of this paper is to explore the influence of processes of learning in organization on innovation performance in high-tech small firms. After reviewing the literature on learning and innovation, the author defines the concepts of knowledge management, organizational learning and learning organization and how they are interlinked. Hypotheses regarding the link between learning organization and innovation are presented. An original construct, based on 6 dimensions, is derived to evaluate the degree of learning in firms. The validities (reliability, unidimensionality and convergent validity) of the construct are assessed using confirmatory factor analysis. Then, the influence on innovation is tested through structural equation modelling (SEM) on a database of 110 US high-tech small firms from different industries. Specifically, influence on product and process innovations and financial performance are tested. The first results show that the presence of learning organization orientation and learning organization processes is related to innovativeness in our sample of high-tech small firms. The results are moderated by the degree of maturity of the industries and the strategic orientation of the CEOs. The conclusive part gives ways to ameliorate the learning organization processes and thus enhancing the innovative performance.

INTRODUCTION

Organizational learning is now a part of management theory vocabulary. Several factors explain this. (Harvey & Denton, 1999 : 897). First of all, the crucial assets for companies have moved from production to capital to labor and finally, to intellectual capital. Secondly, the phenomenon of globalization and acceleration of the businesses put the emphasis on the companies' awareness of their environments. Finally, according to resource-based theory (Wernefelt, 1984 ; Prahalad & Hamel, 1990 ; Grant, 1991, 1996a, 1996b), knowledge is presented as the main source of competitive advantage (Nelson & Winter, 1982 ; Winter, 1987). As such, competitiveness is related to the firm's ability to create knowledge, manage it and to learn faster than its competitors (Easterby-Smith, Snell & Gherardi, 1998).

1. Learning and its dimensions

As stated by Schein (1997), we do not have a clear understanding of the words 'organizational' and 'learning'. Learning is a fuzzy construct, involving several dimensions or sub-constructs. Yet to date, though several theoretical definitions are available, most of them are not easy to operationalize. Learning encompasses three levels : knowledge management, organizational learning and the learning organization.

1.1. Knowledge management

We define knowledge management as the process of managing knowledge. As such, we limit knowledge management to the activities that do not add value to knowledge. Knowledge management is concerned with the acquisition and communication of knowledge. Knowledge management is at the foundation of organizational learning.

1.2. Organizational learning and its components

What researchers admit is the fact that knowledge is created by individuals (Grant, 1996 ; Spender, 1996) and thus exists outside of the organization. An organization learns through its individuals (Argyris and Schon, 1978 ; Huber, 1991 ; Grant, 1996b ; Spender, 1996).

Kim (1993 : 44) gives a clear example of this :

“ Imagine an organization in which all the physical records disintegrate overnight. Suddenly, there are no reports, no computer files, no employee record sheets, no operating manuals, no calendars, - all that remain are the people, buildings, capital equipment, raw materials, and inventory. Now imagine an organization where all the people simply quit showing up for

work. New people, who are similar in many ways to the former workers but have no familiarity with that particular organization, come to work instead. Which of these two organizations will be easier to rebuild to its former status ? ”

Nevertheless, if knowledge only belonged to individuals, companies could change only through employee turnover (Kogut and Zander, 1992). It implies that knowledge is transformed through its passage in an organization. Organizational learning is more than the sum of learning by individual members of the organization (McKee, 1992). Grant (1996b) recognizes that there are many types of knowledge relevant for the company.

Four critical characteristics are suggested.

- *Transferability* : transferability between companies and inside the company is an important issue regarding knowledge. It relates to the process of knowledge diffusion. As such, the main distinction is made between tacit (or subjective, implicit, personal, knowing-how) and explicit (objective, propositional, knowing-about) knowledge (Polanyi, 1967; Nelson and Winter, 1982; Kogut and Zander, 1992). Explicit knowledge is revealed by its communication, whereas tacit knowledge is revealed through its application. Tacit knowledge cannot be bought “on-the-shelves”. For Nonaka (1994:14), “organizational knowledge is created through a continuous dialogue between tacit and explicit knowledge” at the different intra and extra-organizational levels, i.e. the spiral of organizational knowledge creation. This is what Cook and Brown (1999) refer to as “ organizational knowing”.

Knowledge transfers will be more difficult if knowledge is tacit, complex and systemic (Garud and Nayyar, 1994 ; Winter, 1987). Transferability of tacit knowledge is associated with the concepts of “learning-by” (doing, using,...).

- *Aggregation* : the transferability’s efficiency of knowledge depends on its potential for aggregation (Grant, 1996b). The notion of absorptive capacity has been developed (Cohen and Levinthal, 1990). It refers to the capacity to add new knowledge to existing knowledge, i.e. to recognize, assimilate and apply it. It is close to the idea of transformative capacity used in core competencies management (Garud and Nayyar, 1994). Aggregation will depend on the degree of transferability of knowledge.

Because of the informal nature of tacit knowledge, managers have to overcome the “Daphne-dilemma” (Van Aken and Weggeman, 2000) : too little management effort may lead to an under-exploitation of tacit knowledge, but too great an effort may destroy its informal nature and thus part of its value.

- *Appropriability* : refers to the ability of the owner of a resource to receive a return equal to the value created by that resource (Grant, 1996b ; Teece, 1987). As such, tacit knowledge is difficult to appropriate because its transferability is difficult. Nevertheless, as explicit knowledge may be available to everyone, except through patenting, the ownership may be discussed and as a consequence, its appropriability can also be discussed.
- *Specialization* : Efficiency in knowledge requires specialization. As presented by Grant (1996b : 112) : “Jacks-of-all-trades are masters-of-none”. Investing in knowledge depth (through technical specialists) is also important for the adoption of innovations (Dewar and Dutton, 1986). An increase in depth of knowledge implies reduction in breadth (Grant, 1996a).
- *Knowledge requirements of production* : in line with our view, a knowledge theory must make the assumption that knowledge is the main input and source of value.

In the same vein, Huber (1991) distinguished four constructs: Knowledge acquisition, Information distribution, Information interpretation and Organizational memory and Nevis et al.(1995) derive a three-stage model: knowledge acquisition, knowledge sharing and knowledge utilization. From the knowledge management processes, the assimilation process or organizational memory seems to be the most difficult to apprehend (Huber, 1991 ; Nevis et al., 1995).

From the presentation below, it is clear that organizational learning is a process or a set of organizational processes. “If we conceptualize each component of knowledge as a stock, then, the underlying learning processes that create them represent flows” (Garud, 1996 : 5). The different flows are differentiated by their occurrence levels (Argyris and Schön, 1978 ; Senge, 1990 ; McKee, 1992), as single-loop (or corrective), double-loop (or generative) and meta - (or institutional) learning. Moreover, the benefits and side effects of learning processes are unclear.

On the one hand, competency traps may occur because “prior innovative successes reinforce established routines even as the technological frontier shifts to new areas” (Sorensen and

Stuart, 2000 : 87). As companies' experience grows, so do their competences and they become less able to assimilate and exploit new information. Accumulation of knowledge through experience, or learning-by-doing, may lead to failing-by-knowing. This myopia of learning (Levinthal and March, 1993) may see technological leaders replaced by start-ups (Abernathy and Utterback, 1978).

On the other hand, Myers and Marquis (1996) found that small firms that made fewer changes in their successive products, in terms of technology and market, perform better than firms that emphasize more diversity, thus advocate for strategic focus. Zirger and Maidique (1990) also argued that firms must choose development projects that use the existing organizational, marketing and technological competences.

Based on the literature, we define organizational learning as the organizational processes aimed at adding value to the knowledge acquired and communicated throughout the firm. As such, organizational learning processes encompass the acceptance and the assimilation of knowledge.

1.3. The learning organization

Senge (1990 : 3) defines a learning organization as an organization “where people continually expand by their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together”.

Based on previous works (e.g. Day, 1994 ; Senge, 1990 ; Argyris and Schön, 1978), Sinkula et al. (1997) derive the core components of a learning orientation:

- *Commitment to learning* : simply stated, if an organization does not believe in learning, learning may not occur.
- *Open-mindedness* : related to the idea of competency trap or core rigidities, an organization must be able to challenge the existing situations, or unlearn (Nystrom and Starbuck, 1984).
- *Shared vision* : a shared vision influences the direction, or focus of learning.

For the authors, these conditions are necessary for learning to occur. In the same vein, Nevis et al. (1995) define 10 ‘facilitating factors’, involving different organizational characteristics.

We define a learning organization as an organization that is committed to learning. By committed, we mean that the organization is ready to change the way it does things by combining existing knowledge or incorporating new knowledge. Thus, organizational learning processes are neither necessary nor sufficient conditions for a learning organization. But, the existence of organizational learning processes will help the organization to learn.

2. Learning and Strategic Management

If knowledge is the common underlying input in organization and organizational learning is the process of adding value to knowledge, then the organizational learning processes are intimately linked to the strategic management of the company.

Regarding core competencies, Prahalad and Hamel (1990 : 82) recognized that “the skills that together constitute core competence must coalesce around individuals whose efforts are not so narrowly focused that they cannot recognize the opportunities for blending their functional expertise with those of others in new and interesting ways”.

Strategy and organizational learning are determined by each other (Fiol and Lyles, 1985) and the process is nurtured by complementary external and internal information flows (i.e. knowledge management) (Rothwell and Dodgson, 1991).

In a fit perspective, Zack (1999) puts the emphasis on the potential strategic and knowledge gaps. As a gap may exist between what a firm must do to compete and what it can do (strategic gap), a knowledge gap may occur between what the firm must know to implement its strategy and what it actually does know.

Thus, we can say that organizational learning is the process that should lead to the building of a firm's competencies and that a valuable learning experience will lead to firm-specific, distinctive competencies.

Organizational learning is a strategic process and a learning organization is the output of this process that will allow the development of new or regenerated core competencies and products.

From a strategic perspective, we define the firm performance as a by-product of its capacity to develop a learning organization, itself the by-product of organizational learning. An efficient use of knowledge requires congruence between the knowledge domain of the firm and its competencies. The primary task of management is establishing the coordination necessary for knowledge integration (Grant, 1996b), thus enabling organizational learning processes. The relationship between strategy-learning fit and organizational performance would seem to deserve empirical study (McKee, 1992).

3. Learning and Innovation

As for innovation, learning may occur at the individual, group, organization and industry levels (Shrivastava, 1993). As new outputs, innovations may come from new knowledge as well as from the combination of existing knowledge to create architectural innovations (Henderson and Clark, 1990), using combinative capabilities (Kogut and Zander, 1992). Radical and incremental innovations refer to high and low degrees of new knowledge (Dewar and Dutton, 1986), involving high and low degrees of organizational transformation. As such, single-loop learning is related to incremental organizational, product or process innovations, double-loop learning to radical organizational, product or process innovations whereas meta-learning could be related to the processes surrounding these innovations.

Thus, is there a difference between learning and innovating ? As researchers argue that learning means integrating new knowledge or mixing existing knowledge in different ways, learning leads to newness, and thus to innovation. To pursue on the framework presented in the former part, innovation will be the by-product of a learning organization. A learning organization is an innovative organization.

The contribution of the literature to the understanding of knowledge and learning is vast and encompasses different epistemological and conceptual dimensions. As our aim is to develop a definition of learning that is operationalizable, we have to focus on the most concrete determinants of learning. Thus, we can deduce several features from our analysis:

- Organizational learning is a process involving individual, group, organizational and inter-organizational levels
- Learning is concerned with three stages: acquisition, communication and exploitation of knowledge. Acquisition and exploitation will occur again at the different levels suggested above and will be influenced by several factors coming from these same levels. The more

complex, the more tacit and the more systemic knowledge is, the more difficult it will be to acquire and exploit it.

We define the acquisition and communication stage as knowledge management and the exploitation as organizational learning.

- As for any other organizational features, organizational learning processes will be influenced by the strategy of the firm.
- Organizational learning should be positively related to innovation. If a company is good at acquiring new knowledge and articulating existing knowledge with new knowledge or existing knowledge in a different way, this company should be good at producing innovations (product or process). Furthermore, the better the organizational learning process is, the greater the capacity to develop radical innovations (product or process) will be.
- Organizational learning is not necessarily related to innovation's success. Innovation and innovation's success are two different dimensions. A successful learning organization leads to the capacity to innovate (Burns and Stalker, 1961), which is the ability of the organization to adopt or implement new ideas, processes, or products successfully (Hurley and Hult, 1998).

Specifically, if the innovation is not in line with the strategy and the environment of the firm, the innovation may fail and thus the learning-innovation link will not be related to performance. Learning more or faster does not imply that you learn what you have to in order to perform better than your competitors.

Concerning the semantic debate regarding the different definitions of organizational learning and the learning organization, our work leads us to separate both concepts in term of state. For us, organizational learning is a process, whereas the learning organization is a state, or one is a set of tasks, whereas the other is a mindset or culture. We disagree with the distinction made in the literature between organizational learning and the learning organization that relates the first one to how a company *does* learn and the second to how the company *should* learn (Tsang, 1997 : 75). "A learning organization is one which is good at organizational learning". A company could be learning oriented, meaning it is willing to learn and does learn and that makes it a learning organization, but one that is poor in terms of processes that lead to learning, that is organizational learning. Thus, questions remain concerning the bridges

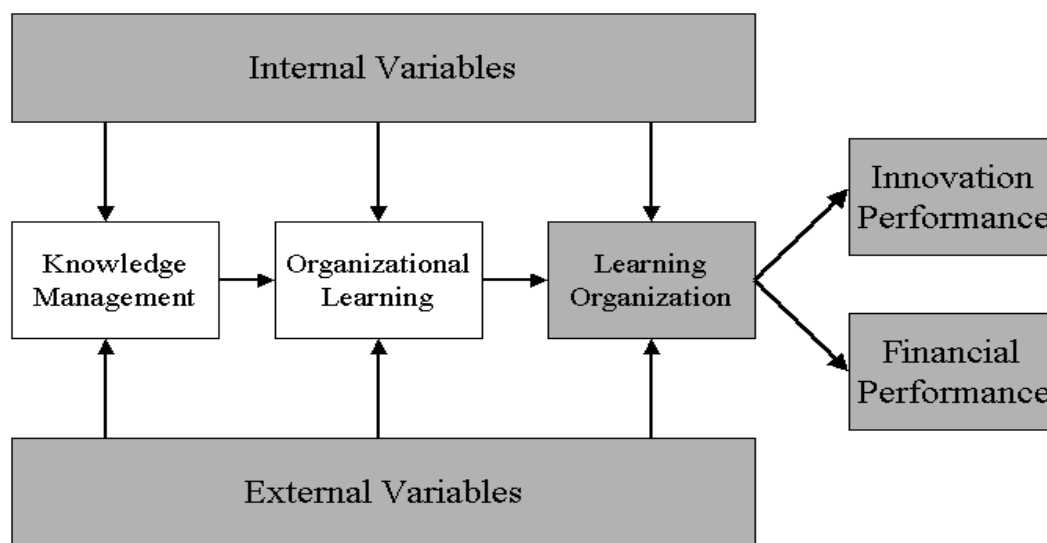
between knowledge and organizational learning, organizational learning and the learning organization, the learning organization and innovation, and innovation and performance. Specifically, what are the constituents or variables that favor or impede a successful passage from one level to an other.

4. Conceptual framework, hypotheses and operationalization

Based on the literature review, the general model underlying our work is represented by Figure 1.

In this paper, we focus on the links between the learning organization and innovation and financial performance. Besides these links, several internal and external variables may influence the level to which a company is a learning organization in companies and thus the links with the performance.

Figure 1 : Conceptual Framework ^a



^a Shaded areas show the variables focused in this paper

4.1. Hypotheses

Based on the conceptual literature on learning (Nevis et al., 1995 ; Leonard-Barton, 1997 ; Sorensen & Stuart, 2000), a learning organization will get accurate internal and external information and use it in an effective way and thus have a better performance than the others.

Hypothesis 1 : Being a learning organization has a positive influence on innovation performance.

***Hypothesis 2* : Being a learning organization has a positive influence on financial performance.**

Regarding the internal variables, we focus mainly on strategic orientation (Venkatraman, 1989). Strategic orientation encompasses 6 dimensions: aggressiveness, analysis, defensiveness, futurity, proactiveness and riskiness. Following Senge (1990) and Zack (1999), defensive strategies have a tendency to cover up problems, whereas aggressive strategies are oriented toward knowledge exploration and exploitation. Analysis strategies are related to a careful definition of the strategic process to integrate various elements in the decision. The contrary occurs for proactiveness and riskiness. Finally, forecasting, long-term resource allocation and basic research, and thus, the willingness to learn characterize futurity.

Hypothesis 3 : Defensiveness strategy has a negative effect on the learning organization.

Hypothesis 4 : Aggressiveness strategy has a positive effect on the learning organization.

Hypothesis 5 : Analysis strategy has a positive effect on the learning organization.

Hypothesis 6 : Proactiveness strategy has a negative effect on the learning organization.

Hypothesis 7 : Riskiness strategy has a negative effect on the learning organization.

Hypothesis 8 : Futurity strategy has a positive effect on the learning organization.

Regarding the environment, because we are dealing specifically with small firms operating in high-tech environments, the stage of maturity of the industries where the firms compete may influence the learning organization. Specifically, in emerging environments, the risk of technological breakthrough is high until a dominant design appears (Olleros, 1986). As such, having an efficient learning process is crucial.

Hypothesis 9 : Stage of Maturity has an influence on the learning organization.

4.2. Sample and operationalization of the constructs

A sample of 1000 companies whose names were gathered from the Hoovers directory of companies in 1999 was chosen to collect data. The questionnaire was mailed out in September 2000 to the CEO or President of the company. The companies were chosen based on their affiliation with the technology sectors and their size (less than 500 employees). Questionnaires were answered mainly by the CEO or the President or Vice-Presidents of the companies. The average job tenure was 7.7 years. The result was 110 questionnaires. The companies studied have an average age of 18 years (S.D.=12). 50.9 % of the companies are privately owned, 45.4 % are public, while the remaining 3.7% are subsidiaries of other companies. The average number of full-time employees is 88, with numbers ranging from 4 to 465. The sales for 1999 have an average of 25.8 million USD (S.D.=99.8), with an export rate of 24.7 %.

Our constructs were built using sets of perceptual questions (7-points Likert scales) answered by the CEOs or Presidents of the companies. The main constructs are presented in Appendix A. Constructs on the strategic orientation are derived from Venkatraman (1989). The financial performance construct is based on perceptual measures (Lefebvre & Lefebvre, 1996 ; Sapienza, Smith & Gannon, 1988). Constructs on innovation performance, learning and maturity are original. Based on Venkatraman and Grant (1986), our constructs were assessed in term of unidimensionality, convergent validity, reliability and discriminant validity. Unidimensionality and convergent validity are assessed using a confirmatory factor analysis (CFA). No consensus exists regarding the indexes used to estimate CFA. Based on the literature (Bagozzi & Yi, 1988 ; Kline, 1998), we use the p associated with the chi-square statistic (p should be higher than 0.1), the CFI and NNFI (both should be higher than 0.9). Reliability is assessed using the Cronbach alpha indicator. The method used is the maximum likelihood with estimation of means and intercepts for missing variables (Amos 4.0). This method has proven to be better than replacing missing values (Kline, 1998). Nevertheless, we found that it has a tendency to “over fit” the model. As such, a very conservative approach is necessary for the goodness-of-fit statistics. CFI and NNFI results below .98 will be considered as poor fit.

5. Statistical analysis and results

Characteristics of the constructs and results of the CFA are presented in Table 1.

Table 1 : Assessing the constructs validities

| Construct | Nb of items | Reliability | P | CFI | NNFI |
|-----------------------|-------------|-------------|------|------|------|
| Learning | 6 | .88 | .102 | .998 | .994 |
| Defensiveness | 4 | .72 | .145 | .998 | .992 |
| Aggressiveness | 3 | .68 | .536 | 1 | 1 |
| Futurity | 5 | .65 | .666 | 1 | 1 |
| Proactiveness | 3 | .54 | .06 | .996 | .979 |
| Riskiness | 4 | .67 | .483 | 1 | 1 |
| Analysis | 5 | .79 | .31 | .999 | .998 |
| Innovation | 4 | .84 | .05 | .997 | .986 |
| Financial performance | 4 | .77 | .75 | 1 | 1 |
| Maturity | 3 | .78 | .31 | 1 | 1 |

The chi-square is questionable for Innovation and Proactiveness. Nevertheless, following Yli-Renko, Autio & Sapienza (2001) and Hair, Anderson, Tatham & Black (1995), we focus mainly on the other indexes and use the chi-square statistics mainly for model comparison. Cronbach Alpha, CFI and NNFI are satisfactory for all the constructs and validate them in term of reliability, unidimensionality, and convergent validity. Results for discriminant validity are also satisfactory and are available on request.

The different hypotheses were tested through path models (Table 2) including the cause construct and the effect construct. RMSEA score was added (should be lower than .1).

Table 2 : Testing the Hypotheses

| HYPOTHESES | χ^2 | CFI | NNFI | RMSEA | Loading | R ² |
|---------------------------------------|----------|------|------|-------|---------|----------------|
| H1: Learning → Innovation Performance | 46.5† | .997 | .995 | .058 | .464*** | .216 |
| H2: Learning → Financial Performance | 49.2* | .996 | .993 | .064 | .329** | .108 |
| H3: Defensiveness → Learning | 77.99*** | .987 | .979 | .109 | .387** | .15 |
| H4: Aggressiveness → Learning | 36.21† | .997 | .994 | .06 | .29* | .08 |
| H5: Analysis → Learning | 63.47* | .995 | .992 | .066 | .36* | .13 |
| H6: Proactiveness → Learning | 54.43* | .991 | .985 | .1 | .763** | .582 |
| H7: Riskiness → Learning | 54.24* | .994 | .990 | .074 | .540*** | .292 |
| H8: Futurity → Learning | 71.25** | .992 | .988 | .078 | .467** | .218 |
| H9: Stage of Maturity → Learning | 41.47* | .996 | .993 | .07 | .247* | .06 |

† p<.1, * p<.05, ** p<.01, *** p<.001

Statistically, these results necessitate several comments. The analysis for H3 cannot be validated as it has a very significant chi-square and unsatisfactory CFI and NNFI. In the same vein, H6 and H8 must be interpreted with caution. Regarding the other hypotheses, even if the chi-square is significant, the other indexes achieve acceptable results. Thus, we have contrary results for H6 (Proactiveness) and H7 (Riskiness), which both have a positive influence, whereas a negative one was hypothesized. All the other hypotheses are validated. Finally, for all the validated hypotheses, we have strong and significant loadings, with R^2 ranging from 6% to 58 %.

Regarding the influence of learning, positive results are found for the innovation performance and the financial performance. Developing a learning organization positively influences the performance of high-tech small firms. Furthermore, the influence is more important on innovation ($R^2=21.6\%$) than on financial performance ($R^2=10.8\%$), suggesting a tighter link between both.

Concerning the different strategic orientations that could influence the learning organization, all the dimensions have a positive influence. This suggests that there is no strategic behavior that inhibits learning. Nevertheless, some dimensions have a more important influence than others, in order of importance, proactiveness, riskiness and futurity. On the other hand, aggressiveness and analysis have a positive but smaller impact.

Regarding the influence of the environment, as expected, the stage of maturity influences the learning organization. The more emerging the environment is, the more learning the organization develops. Nevertheless, it has only a small influence on the learning orientation of the companies.

6. Discussion

This first empirical insight on learning in small high-tech firms shows that our main findings are in line with the literature developed on the subject in the last ten years. Developing a learning organization is strongly related to the performance of the companies, in terms of finance and innovation. As presented previously, our definition of a learning organization encompasses the behavioral aspects of learning or orientation toward learning, not the specific processes underlying its occurrence (knowledge management and organizational learning). As such, it is interesting to deepen the understanding of the facilitators of learning.

The different strategic postures studied all lead to more learning in the firms. It implies that there is no one-best way in terms of strategic orientation to favor learning. Proactiveness and Riskiness were found to have the greatest influence on it. Taking risks and searching for new or different paths for the company is related to the orientation toward using new knowledge and building on it. On the other side, Aggressiveness has the smallest influence. This dimension relates mostly to the search for the biggest market share, to beat competition at any price. This 'basic' strategy is very far from the careful incorporation of knowledge in the company.

Finally, regarding the environment, the maturity has a small influence on the learning organization. If learning is found more in companies operating in emerging environments than in those operating in mature environment, it is definitely not the most influential factor.

6.1. Implications for managers

In term of practical tools for managers, this study shows that developing a learning organization is beneficial to the companies in term of innovation and financial performance. As such, managers should put the emphasis on the behaviors or processes that will make employees aware of the necessity to use information coming from the inside and the outside of the company.

Unfortunately, the fact that all the strategic orientation dimensions have a positive influence on learning does not allow them to derive a clear strategy to favor learning in the company, even if proactiveness and riskiness are the most influential in our context of small high-tech firms.

6.2. Limitations, conclusion and further research

From an empirical perspective, this paper allowed us to develop and test an original construct to measure the learning organization dimension in companies. The first encouraging results show that this construct achieves reasonable validities. As such, we encourage authors to test it in other contexts to refine it.

Nevertheless, several limits are raised. First of all, the small sample used and its specificities (high-tech small firms) limits the generalization of the construct. Secondly, the several tests on the influence of the strategic orientation on learning suggest that a mix of dimensions,

more than on alone, are related to the learning organization. Once again, the small number of companies studied does not allow us, in term of statistical validity, to build and test a model with all the six dimensions of the strategic orientation.

The first results let us think that we are on an interesting track but that further research is definitely needed to fully understand this complex phenomenon, that is beneficial for the performance of companies.

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Appendix A : Measurements of the main constructs

| Learning Organization | Mean | S.D. |
|--|-------------|-------------|
| Our company: | | |
| Is quick to learn new concepts or ideas | 5.31 | 1.32 |
| Learns from its past mistakes | 5.54 | 1.15 |
| Has an organizational culture that encourages learning new ideas, concepts and methods | 5.75 | 1.06 |
| Promotes the sharing of ideas across different units or functions | 5.85 | 1.17 |
| Is good in combining different technologies to develop new products, goods or services | 5.43 | 1.32 |
| Is very slow to recognize new ideas or practices developed in-house (rev) | 5.80 | 1.21 |

All items are rated on a 7-point Likert-scale (1= Totally disagree ; 7= Totally agree).

| Innovation Performance | Mean | S.D. |
|--|-------------|-------------|
| Product Innovation | 5.34 | 1.37 |
| Adoption of new product technologies | 5.25 | 1.15 |
| Adoption of new process technologies | 4.93 | 1.35 |
| Transforming R&D results into products | 5.11 | 1.37 |

Evaluation of the company's performance over the past three years compared to the major competitors (1= Much worse; 7= Much better)

| Financial Performance | Mean | S.D. |
|------------------------------|-------------|-------------|
| Sales growth | 4.85 | 1.51 |
| Benefits | 4.77 | 1.18 |
| Return on Sales | 4.72 | 1.23 |
| Return on investment | 4.73 | 1.44 |

Evaluation of the company's performance over the past three years compared to the major competitors (1= Much worse; 7= Much better)

| Stage of Maturity | Mean | S.D. |
|--------------------------|-------------|-------------|
| Major Market | 5.65 | 1.25 |
| Major Industry | 5.35 | 1.14 |
| Major Technologies | 5.59 | 1.26 |

All items are rated on a 7-point Likert-scale (1= Mature ; 7= Emerging).